



NASA Engineering and Safety Center

The NASA Engineering and Safety Center's First Year of Operation

In its first year of operation, the NASA Engineering and Safety Center (NESC) has demonstrated the ability to perform value added independent technical assessments, analyses, and tests by calling upon an impressive network of several hundred experts from across all NASA Centers, other government agencies, industry, and academia. While a majority of the NESC's efforts in FY04 have been in support of the Space Shuttle and International Space Station (ISS) Programs, the NESC has also assessed high-risk programs across the Agency, including CALIPSO, Cassini, Genesis, Hubble Space Telescope, and X-43. A significant portion of NESC funding goes directly to conducting these independent assessments and associated analyses and tests.

The NESC accepts requests for involvement from all across the Agency, as well as from numerous external sources. All requests for potential NESC involvement are reviewed and acted upon in a timely manner. In FY05, a new Web-based request system will be available for NESC customers to track the progress of their requests.

Lessons learned are being captured from all NESC activities. In addition to submitting these lessons to the NASA Lessons Learned Information System, the NESC also presents the broadly applicable lessons to the Agency's senior leaders in biannual Leadership Briefings. Working with the Office of the Chief Engineer and the Safety and Mission Assurance community, the NESC ensures that implementation plans are developed and executed for each of these broadly applicable lessons learned.

Data Mining and Data Trending

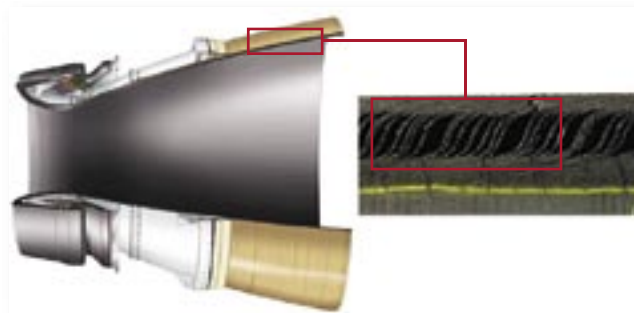
The NESC has assumed the lead for independent technical data mining and trending in the Agency. The goal is to find unknown indicators of future problems, not to duplicate a project or program's specific trending efforts. Data critical for detecting these indicators exist in a plethora of dissimilar nonconformance databases without a common format or taxonomy. The NESC's near-term plans include holding workshops to review best practices and pitfalls in the areas of data mining and trending, developing a common data taxonomy to facilitate trending objectives, and benchmarking electronic tools to facilitate data mining and trending.

NESC Space Shuttle and International Space Station Recurring Anomalies

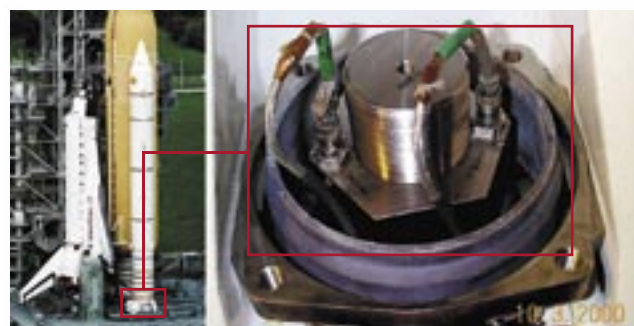
The NESC formed a multidisciplined independent team to review recurrent Space Shuttle and ISS technical problems and ensure that identified risks are understood and addressed by the program.

The NESC Recurring Anomalies Review Team is organized around eight discipline-centered subteams whose members review and assess program problem reports, corrective action, and flight rationale. As the review of Space Shuttle Program data nears completion, a number of issues have been identified for further program action. The NESC has initiated further investigations into several of these identified areas of concern, including reusable solid rocket motor nozzle ply lifting and solid rocket booster hold-down post stud hang-up.

After completion of the Space Shuttle review, the NESC Recurring Anomalies Review Team will begin to assess the International Space Station Program. Future activities for this team will include the development of tools and techniques for long-term data mining and trending across all NASA programs.



Ply lifting of reusable solid rocket motor nozzle.



Solid rocket booster hold-down stud and explosive nut.

NESC Technical Activities Yield Lessons for Agency

Orbiter Main Propulsion System Liquid Hydrogen Feedline Flowliner

Inspections of the liquid hydrogen (LH₂) feedlines to the Space Shuttle main engines (SSME) revealed cracks at the slots in the gimbal joint flowliners, which protect the bellows and direct the LH₂ into the SSME. All cracks were repaired through welding and all slot edges were polished to remove defects that could initiate new cracks. Subsequent ground tests conducted in the SSME test stand at Stennis Space Center resulted in measured strains considerably higher than expected in two different flowliner test articles. These results cast doubt on the long-term validity of the postrepair flight rationale.

Responding to a request from the Orbiter Project Office, the NESC determined that the most likely root cause of the cracks was high cycle fatigue caused by flow-induced vibration. Crack initiation and growth was accelerated by stress concentrations due to slot geometry and surface defects from the manufacturing process. The most difficult technical challenge to overcome in the assessment was the high degree of uncertainty in the loads acting on the flowliner. This uncertainty resulted from differences between the ground test article and the flight hardware. To analyze the flowliner issues, the NESC developed a refined three dimensional fracture mechanics analysis method that coupled crack growth kinetics directly to structural dynamics. The NESC also developed a high fidelity inspection method for in situ examination of flowliner slots. The results of these efforts helped the Orbiter Project Office develop a flight rationale for flowliner flight certification.

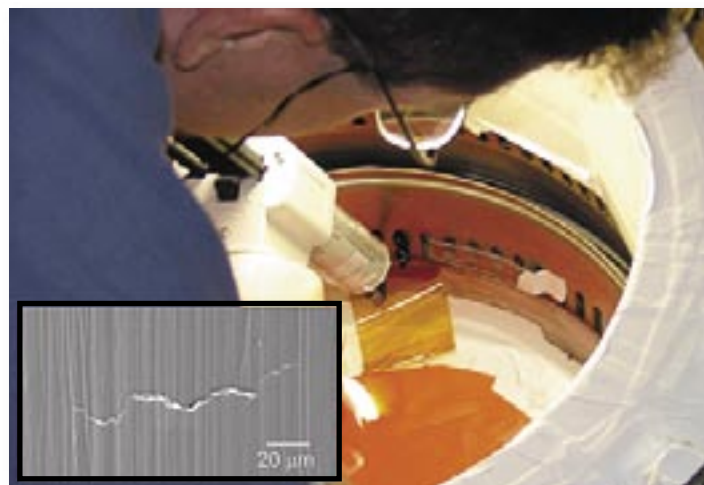
Lesson: Ground testing should be conducted in a configuration as close to flight as possible. Where differences between ground and flight configurations or environments are necessary, every effort to correlate the ground test data to actual flight situations must be made. Complex subsystems like propulsion may require ground test articles to be maintained throughout a program's lifetime.



SSME LH₂ feedline with flowliner (inset).



The HST is expected to remain operational through 2008.



Flowliner slot inspection and crack (inset).

Hubble Space Telescope Life Extension

The Agency is currently investigating alternative servicing concepts for the Hubble Space Telescope (HST). Two efforts in support of these activities involved NESC assessments of nickel-hydrogen (Ni-H₂) battery remnant life and overall system health of the HST. These consultations generated recommendations that

aided in an Agency decision to continue the robotic service mission concept to the Critical Design Review phase.

Several observations were identified during these consultation efforts. One observation resulted from the fact that the battery bays were not redesigned when the nickel-cadmium batteries were replaced with Ni-H₂ batteries. This change resulted in a narrow heat dissipation margin, which in turn constrained the options for battery capacity maintenance. Another observation was that while a total ionizing dose exposure level evaluation was performed for the 15-year design life of the original HST electronic components, it was not readily verifiable that an updated analysis was performed for the 2013 end-of-life.

The NESC also recognized the HST Program's foresight in maintaining skilled operations and sustaining engineering experts capable of observing subtle performance changes, generating inventive work arounds, and preparing multilevel contingency plans. In addition, the HST Program's commitment to retain engineering units and test facilities enabled verification of proposed enhancements and proved invaluable in demonstrating the robotic servicing concept.

Lesson: Capability of a system's original hardware requires verification following any changes in operating environments from planned performance and life extension upgrades.

Lesson: Design changes occurring late in the development phase should be thoroughly evaluated by all engineering disciplines to minimize the risk for unforeseen operational constraints and limitations.

Lesson: Maintenance of high fidelity engineering units and mock-ups is vital to developing and certifying hardware and software improvements on the ground before implementation on-orbit.

Lesson: Proper selection, preservation, and development of an operations and sustaining engineering workforce is critical to identification of emerging performance trends and generation of innovative corrective actions.



HST batteries (flight spares).

Space Shuttle Reaction Jet Driver

Four avionics boxes on each Space Shuttle Orbiter, known as reaction jet drivers (RJD), control the thrusters that are used for orbital maneuvering. A failed-on primary thruster could be catastrophic during mated operations with the International Space Station. An NESC assessment of this scenario focused on two failure modes: shorting of the RJD transistor switch and a "smart" wire-to-wire short between a power wire and a thruster command wire.

Whereas some of the transistors and wires in the Orbiter fleet are 25+ years old, no data exist on aging effects and no test is currently available to assess age degradation of Shuttle's Kapton® wiring. The various probabilistic risk assessments (PRAs) performed by both the Shuttle Program and the NESC produced a wide range of results. All transistor PRAs used MIL-HDBK-217 as an absolute source for field (in-service) failure prediction, despite the handbook's known limitation as a design trade tool.

Because of uncertainty in various PRAs, the NESC, in coordination with the Shuttle Program, is conducting electrical characterization testing and a destructive physical analysis of RJD transistors from flight assets to determine the potential effects of aging and manufacturing defects. The NESC also recommended adding a new preflight leakage current test to assess transistor health and replacement of RJD command wires with new, better protected wiring that would be separated from power wires. Both recommendations are under consideration by the Shuttle Program and will be discussed jointly with the ISS Program for final disposition.



RJD electronic components and wiring (inset) are undergoing analysis. Endeavour's forward thrusters are visible.

Lesson: Programs that share physical interfaces, and therefore risks, should ensure that responsibility for integrated hazards is clearly defined and that the system requires periodic reviews of these hazard reports.

Lesson: Effects of aging, operation, and environmental exposure should be factored into expected operational life of new vehicle designs. Reliability prediction methods should include aging effects.

Lesson: MIL-HDBK-217 is not suited as an absolute quantitative tool to predict the likelihood of electronic part failures in space systems and does not include parts aging, leading to potential overestimations of part reliability.

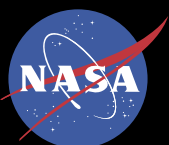


Other NESC activities:

- Assessment of the structural integrity of the Orbiter wing leading edge spar and reinforced carbon-carbon attachment hardware
- Field Programmable Gate Array (FPGA) testing and verification and validation
- Stratospheric Observatory for Infrared Astronomy (SOFIA) acoustical resonance investigation
- Improved Non-Destructive Evaluation (NDE) for the Shuttle external tank
- Concept validation for elimination of liquid nitrogen at the external tank intertank flange
- Independent modeling of entry, descent and landing of the Cassini-Huygens probe
- Inspection of the Shuttle/ISS Micro Meteoroid Debris model (BUMPER)
- Support to the Genesis mishap investigation

For more information on the NESC, the contents of this brief, or to report a technical concern, please visit our Web site: <http://nesc.nasa.gov>

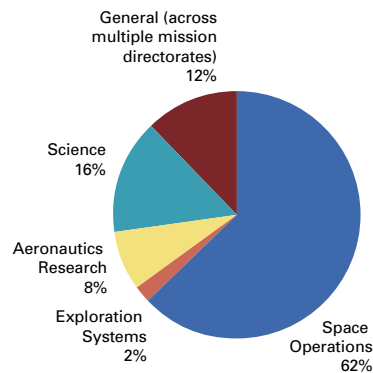
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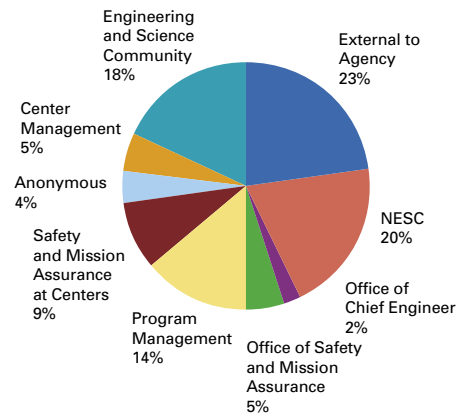
Metrics

During its first year of operation, the NESC has seen a steady increase in requests for its technical expertise with a total of 85 requests processed by the end of FY04.

NESC Requests by Mission Directorate



Sources of NESC Requests



NESC Honor Awards

The first NESC Honor Awards were presented during the Leadership Briefing on May 12, 2004, at NASA Headquarters. NESC Director Ralph Roe and Chief Safety and Mission Assurance Officer Bryan O'Connor gave opening remarks. STS-114 Commander Eileen Collins and Mission Specialist Charles Camarda presented awards to five recipients.

The NESC Director's Awards were presented to Mr. Richard M. Wood (LaRC) and Mr. Erwin V. Zaretsky (GRC). The NESC Engineering Excellence Award was presented to Mr. Timothy R. Jett (MSFC). The NESC Leadership Awards were presented to Mr. Luat T. Nguyen (LaRC) and Dr. Michael G. Ryschkewitsch (GSFC).



*NESC Honor Awards May 12, 2004, at NASA Headquarters.
From left to right: Bryan O'Connor, Charlie Camarda, Luat Nguyen, Michael Ryschkewitsch, Timothy Jett, Mike Gilbert accepting for Richard Woods, Erwin Zaretsky, and Eileen Collins.*